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NR. 3. A. STRUBBERG: THE METAMORPHOSIS OF ELVERS AS INFLUENCED BY OUTWARD CONDITIONS. SOME EXPERIMENTS.

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THE METAMORPHOSIS OF ELVERS AS INFLUENCED BY OUTWARD CONDITIONS

SOME EXPERIMENTS

BY

A. STRUBBERG

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1913

In "Remarks on the metamorphosis and distribution of the larva of the eel (Anguilla vulgaris Turt.)"[1] Johs. Schmidt mentions among the conditions which concern the transformation of the eel the question of the conditions which determine the developement of pigmentation in elvers.

On the basis of some experiments which he had made with colourless (unpigmented) elvers, placed partly in fresh and partly in saltwater (from the southeastern North Sea), he maintained that the developement of the pigment appeared to commence and proceed more or less simultaneously in both cases. He is therefore of opinion, that the commencement and progress of the developement of the pigment as well as the metamorphosis generally, must be dependent upon some other circumstances than these outward factors; either other outward conditions, or causes inherent in the eel fry itself.

The few experiments which he made under primitive conditions on board the »Thor« (1906) gave no further information: there remained therefore the task of repeating them, under more favourable conditions and on a larger scale. This was done during the spring of 1911 and 1912, in the physiological department of the Carlsberg Laboratory, under the personal supervision of Dr. Johs. Schmidt.

The experiments of 1911 can however, only be regarded as introductory. In the first place, they were made with too few specimens, and were moreover commenced too late, at a too advanced stage of the metamorphosis, to give so clear a view as the experiments made in the following spring (1912). Another unfavourable circumstance, viz, the unusually high temperature in May in 1911[2], served to render the results less distinct.

The elvers were taken in both years from Proprietær Nielsen's Eel farm at Hovvig per Nykøbing (Sjælland). On the 28th of April 1911 a sample of the elvers which had immigrated into the dammed up area[3] was forwarded living in damp sea weed (Ruppia) to the Carlsberg Laboratory. The sample (700 specimens) was divided into three lots. About 300 were killed immediately, and preserved in 2 % formalin. Of the remainder, about 250 were kept at an ordinary indoor temperature, the rest, about 150, being placed in the open air. The elvers were in both cases distributed in aquaria, partly with fresh and partly with salt water; a small number were placed in fresh water in a dark room at ordinary, indoor temperature. All the aquaria were of the same size, with about the same quantity of water (ca. 4 Lit.), and were continually aired throughout the whole period of experiment. The bottom was covered with washed sand, in which most of the fish remained buried all the time, only head and tip of tail being visible. They were not fed as long as the experiments lasted.

After about a month, on the 29th of May, the experiments were stopped, the specimens killed and preserved in 2 % formalin.

[1]) Medd. Komm. f. Havundersøgelser, Fiskeri Bd. III. No. 3. 1909.

[2]) About the middle of the month and towards its close, maximum temperatures were measured at 22—28° C.

[3]) Salinity outside the dame 7.56 ‰ — inside 2.05 ‰.

As regards the results of the experiment, it will here suffice to mention that SCHMIDT's previous experience was fully confirmed; the pigmentation developed with the same rapidity in salt as in fresh water, nor did the darkness appear to have any influence, at any rate, of importance, upon the rapidity of developement of the pigmentation. On the other hand, the experiments seemed to indicate that the temperature must be regarded as a factor of far greater importance.

As already mentioned, however, various unfavourable circumstances necessitated a new series of investigations, modified to some extent according to the results obtained, and it is with the discussion of these that the following is almost exclusively concerned.

On the 2nd of April 1912 about 2000 elvers were caught, and immediately forwarded to Carlsberg Laboratory. About 700 were killed at once, and preserved in formalin (2 %). The remainder were distributed, as shown below, in aquaria, partly in the laboratory, partly in a cellar beneath the building (impermeable to frost) by which means it was possible to have two series of experiments, each with a more or less constant temperature, essentially different for the two series.

Table of Experimental Aquaria. Spring 1912.

Aquarium No.	No. of Elvers	Period of Experiment	Water	Where placed	Min. and Max. Temp. C°	Salinity S °/₀₀
I	266	4. April—16. April	fresh	Laboratory	16—19	—
II	ca. 200	4. » —13. Aug.	fresh	Laboratory	abt. 16—24	—
III	79	4. » —16. April	fresh	Laboratory	16—18.5	abt. 16
IV	141	4. » —16. »	fresh	Laboratory	16—18.5	abt. 16
V	221	4. » —26. June	salt	Laboratory	15—21	19.29
VI	185	4. » —26. »	salt	Cellar	8—16	17.48
VII	324	4. » —16. Apl.	salt	Cellar	7.5—10	16.11

Aquarium No. II was used inter alia for feeding experiments; in all the other aquaria the elvers were not fed.

Aquaria No. V and VI were covered with cardboard in such a manner as to weaken the light without entirely excluding it.

The temperature in Aquarium VI rose until the 24th of April from 8°—13°.5, fell from the 25th—28th to 10°, thereafter rising steadily again through May, up to 13°.5 once more. The rise continued until the middle of June, reaching abt. 16°, whereafter, abt. 14th—19th June, a fall of abt. 4° (to 12°.5) took place, followed later by another rise (19th—27th June) up to 15°.5. The variations in temperature appear again in aquarium No. V (and II), but the difference between the temperatures of these two aquaria (No. V & VI) is generally 4°—7°, only occasionally lower (abt. 2.5—3.5). The temperatures were taken daily at about 9 a. m. and 6 p. m.: the difference between the two readings for each day being either 0° or ½°, only on three occasions 1°—2° (period of 83 days).

At the conclusion of the experiments all the eels were killed in 2 % formalin, and preserved therein.

The three sets of samples thus obtained: the elvers which had been killed immediately, and those killed after a period of 14 days and 2¾ months respectively, were now examined and the degrees of transformation as regards the developement of the pigmentation compared. The average length and average weight of the samples were also determined.

These observations are briefly set forth in the following.

I. DEVELOPEMENT OF PIGMENT.

The material includes all phases, with the exception of the very last of the developement of the superficial pigment, and its spread along the dorsal and lateral surfaces of the body. It is necessary to closely mark the single stages in this developement, in order to be able to differentiate and compare the various samples.

SCHMIDT has given a rough outline[1]) of this side of the metamorphosis, and GILSON[2]) has further detailed SCHMIDT's division into stages according to the character and developement of the pigment. An even closer distinction, however, between the various steps in the change of colour but based throughout upon the foregoing was necessary for our purposes. In referring to the table given below, the following remarks will here suffice.

Only a few especially conspicuous features in the character of the pigmentation have been taken into consideration when making the divisions; such as were easily distinguishable when observing the elvers, through a low-power magnifying lens, against a background of white.

A complete description of the change of colour would lie entirely outside the limits of this work; GILSON's article may be consulted in this respect. The following extracts from his treatise are here given for information.

In its youngest form (Stage V_A Schmidt = Stage V_A Gilson) the elvers posses two systems of pigment, a superficial, subepidermal, connected with she skin, and consisting of brownish pigment-cells, which in this stage are only developed at the extreme end of the tip of the tail; and another, internal system, following the spiral column as a set of black chromatophores.

Then (Stage V_B Schmidt) we find on the dorsal surface of the head the likewise deep-rooted "tache cérébrale" (Gilson). Next (Stage VI_A Gilson; Stage VI Schmidt) the developement of the superficial system proceeds more rapidly. From a "rostral" group of pigmentcells, which make their appearance on the upper side of the snout, close-packed colour cells shoot out over the dorsal and lateral surfaces of the head. At the same time the pigment spreads forward from the tail along the back, and farther, along the myosepta and as a mediolateral line down over the sides of the tail and body. Finally, the developement closes, the original, simple, myoseptal arrangement of the pigment is first doubled, and then (Stage VI_B, Gilson) becomes indistinct, and diffused, by the strong spread of the inter-myosepta pigment.

Our material includes stages V_B—VI_B, only a very few, however, of these last, with completed metamorphosis as regards pigmentation. For the rest, the principles upon which our division is based will be intelligible from the following.

No essential difficulty was encountered in the practical division of the material as below. The preservation of specimens was also most favourable, most of them being placed while still alive in the formalin. Only in three cases, i. e., some of the specimens immediately killed, and four from aquaria III and IV (two from each) was it impossible to determine with certainty the precise group, owing to destruction or accidental removal of the pigment. Only in one case was it difficult, in spite of distinct pigmentation, to classify a specimen, in which, in spite of developed preanal ventrolateral pigment, the fully developed, dorsolateral and mediolateral pigment was not yet apparent as far forward as in the majority.

The examinations were made under a low-power lens in a shallow bowl with white bottom; the few remarks necessary as to details will be found in the following.

Below are given the results of the analyses of the single samples, arranged in such a manner that those most developed are placed farthest to the right.

[1]) Contrib. to the Life Hist. of the Common Eel. 1906.
[2]) L'Anguille, Ann. Soc. roy. Zool. et Malacol. Belg. T. XLIII. 1908.

Table of the developement of pigment in elvers.

Stage of developement of the Pigment	Details of the different stages		Phase of developement in the different stages	Detail of the phases of developement in the different stages
V_B.	No distinct *dorsal* pigment on body or tail.		1 2	Only "tache cérébrale" distinct and "rostral" Pigment present.
$VI_{A.\ I}$	*Dorsal* pigment developed; *no* distinct *mediolateral* do.		1	Pigment in formation along whole of dorsalridge; *Dorsolateral* pigment developes postanally, along the Myosepta. No distinct *Mediolateral* do. (Fig. 1.)
$VI_{A.\ II}$	No preanal ventrolateral pigment	Distinct postanal developement of *mediolateral* pigment.	1	Distinct progress of *Medio-lateral* pigment in rear half of tail.
			2	*Mediolateral* pigment reaches middle of tail.
			3	Do. do. advancing in forepart of tail, but not extending over anus. *Dorsolateral* pigment developing preanally. *Ventrolateral* pigment appears postanally near the end of the tail, here also is seen, dorsolaterally, incipient doubling of the myoseptal series, and intermyoseptal pigment developing.
			4	*Mediolateral* pigment reaches out over the anus. (Fig. 2.)
$VI_{A.\ III}$		Distinct preanal developement of *mediolateral* pigment.	1	*Mediolateral* pigment reaches below front edge of dorsal fin.
			2	Do. do. reaches out over the liver [1]). Postanally, throughout almost entire length, doubling of the dorsal, myoseptal series, and local doubling of mediolateral do. (Fig. 3.)
			3	Do. do. reaches out over pectoral fins. Preanally little or no ventrolateral pigment [2]).
$VI_{A.\ IV}$	Pigment distributed for the most part along the myosepta	Distinct developement of *ventrolateral* pigment preanally.	1	Distinct ventrolateral pigment, present preanally as scattered chromatophora under the mediolateral line. The postanal ventrolateral pigment is stronger, and is distributed along the myosepta. Doubling of the dorsal series (locally) also preanally (Fig. 4.) At this stage the formation of pigment begins, in some few specimens, on the pectoral fins, on the proximal part of the branches of the lower jaw, also behind and below the eye.
			2	Ventrolateral pigment in hinder portion of preanal part of body distributed myoseptally. Increased doubling of the myoseptal and developement of the intermyoseptal pigment, dorsally, and (postanally) ventrally (Fig. 5.)
			3	Ventrolateral pigment developed all along the myosepta, forwards, preanally. No intermyoseptal pigment yet present here.
			4	Distinct doubling of the præanal, ventrolateral myoseptal series and simultaneous developement of the corresponding, intermyoseptal pigment. This latter now in vigorous growth (Fig 6.)
VI_B.	Myoseptal arrangement of pigment, both dorsally & ventrally, begins to be indistinct.		1	Arrangement along »lateral-line« and myoseptal still visible, most distinctly far out on the tail, the pigmentation otherwise diffuse (Fig. 7.) Distinct »cheek pigment« on head, behind and below the eye, and pigment on branches of lower jaw along whole length. Distinct pigment of pectoral fins.

[1]) The position of the liver can always be located at a glance.

[2]) Some specimens, divided among several of the aquaria showed on one side of the body a few (2—4) preanal ventrolateral chromatophores, these being entirely wanting on the other side. These were all reckoned under $A_{III.\ 3}$.

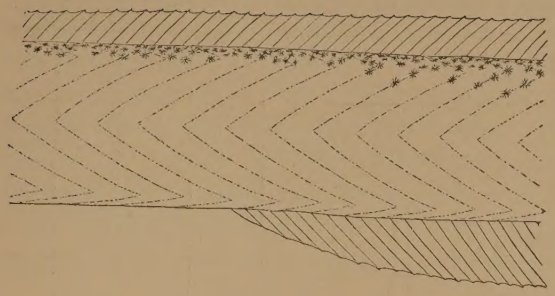

Fig. 1.

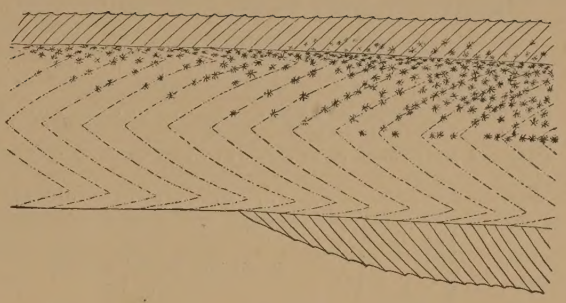

Fig. 2.

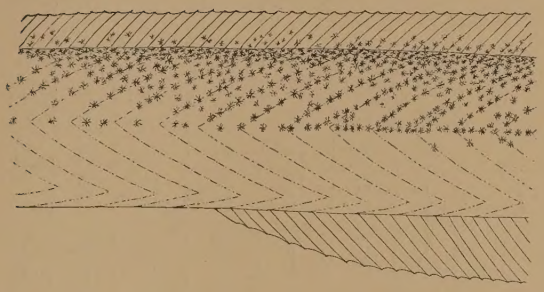

Fig. 3.

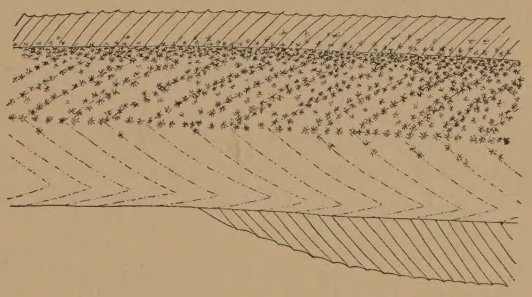

Fig. 4.

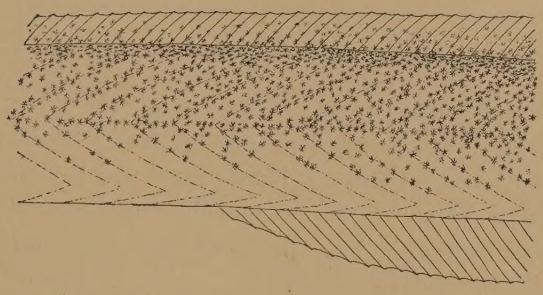

Fig. 5.

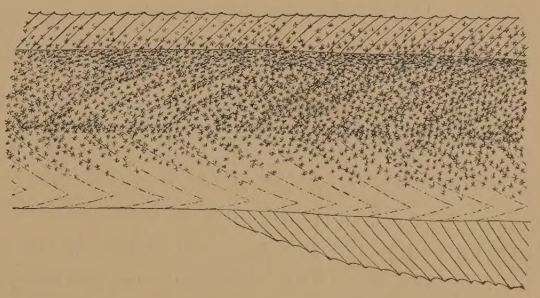

Fig. 6.

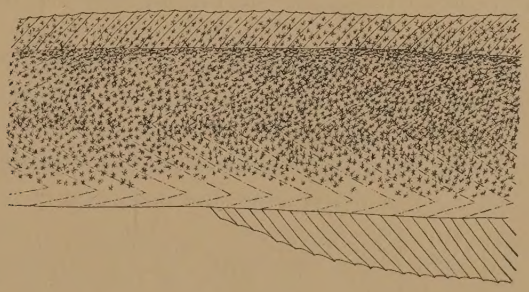

Fig. 7.

Fig. 1—7. Stages in the developement of the subepidermal pigment in Elvers at the transition between body and tail. Slightly schematized.

Number of elvers in the different samples, arranged according to degree of pigmentation.

Aquarium No.			Killed at once	VII	I	III	IV	II	VI	V
Duration of Experiment (days)				12	12	12	12	46	83	83
Min. and Max. Temp. (C°)				7.5–10	16–19	16–18.5	16–18.5	15.5–22	8–16	15–21
Water				Salt	Fresh	Salt	Salt	Fresh	Salt	Salt
	Stadium									
V_B	1	No distinct *Dorsal* pigment on body or tail	108							
			166							
	2		241	1						
$VI_{A.\ I}$	1		69	54						
$VI_{A.\ II}$	1	Distinct *Dorsal* pigment. *Mediolateral* pigment developing postanally	68	16	2		1			
			40	68						
	2		14	82	3	2	13			
	3		13	73	13	11	16			
	4		2	13	19	9	14			
$VI_{A.\ III}$	1	*Mediolateral* pigment developing preanally		5	59	15	22	3	1	4
	2			7	77	19	21	11	11	38
	3			5	57	12	24	48	23	52
$VI_{A.\ IV}$	1	*Ventrolateral* pigment developing preanally			19	5	20	20	33	87
	2				11	4	5	10	26	27
	3				4	1	3	6	46	9
	4				1	1	2	1	37+2?	3
VI_B									4+2?	2
		Total . . .	721	324	265	79	141	99	185	222

As regards the different samples, the following remarks must be added.

1) »Killed immediately«. Stage V_B. In the 108 specimens first noted, the "tache cérébrale" was not visible with the lens. Slightly magnified (under the microscope) and strongly lighted, this was however apparent in all, but with highly contracted chromatophora. This method of examination also revealed, in most of the 108 specimens, a group of faintly developed pigment cells on the snout. The subsequent 166 however, showed a distinct cerebral spot, visible under the lens.

Stage $VI_{A\,II-1}$. In 68 specimens the »mediolateral line« was observed only in the hindmost quarter of the tail; in the following 40 it extended farther forward.

The pigment was very faintly developed in all the specimens of this sample, although distinctly visible under the lens.

2) Aquarium VII. Stage $VI_{A\,II-1}$. Here also a slight difference was observed in the developement of the »mediolateral line« on the tail, which is taken as justifying the present division of the specimens.

3) Aquaria III and IV. The eels from these two aquaria are placed together, having been under absolutely identical conditions throughout the experimental period.

4) Aquarium VI. Stage $VI_{A\,IV-4}$ and VI_B. The 4 specimens noted with a? are presumably here placed in their proper class, but all might possibly rather be regarded as belonging to A_{IV-4}.

A comparison of the degrees of developement within the different samples may already be made from the figures given; the results are shown graphically in Fig. 8.

As already indicated most of the elvers were, at the commencement of the experiments, in Stage V_B,

i. e., without dorsal pigment on body or tail[1]). After the first fortnight of the experimental period, which time alone is taken into consideration (in Fig. 8), all the specimens in Aquarium VII (7.5°—10°), show strong developement of the dorsal and dorsolateral pigment, with a distinct »mediolateral line« on the tail. It is thus evident, that even at this low temperature a distinct and extensive formation of pigment has taken place. Still further advanced however, is the developement in Aquaria III, IV, and I (16°—19°). In the greater number of specimens here, the dorsolateral (and mediolateral) pigment is present in large portions of the preanal part of the body. The influence of temperature as hastening or retarding the developement of the pigment can now no longer be doubted. Comparative congruence of the curves for Aquaria I and III—IV further show, that it is immaterial, at least within

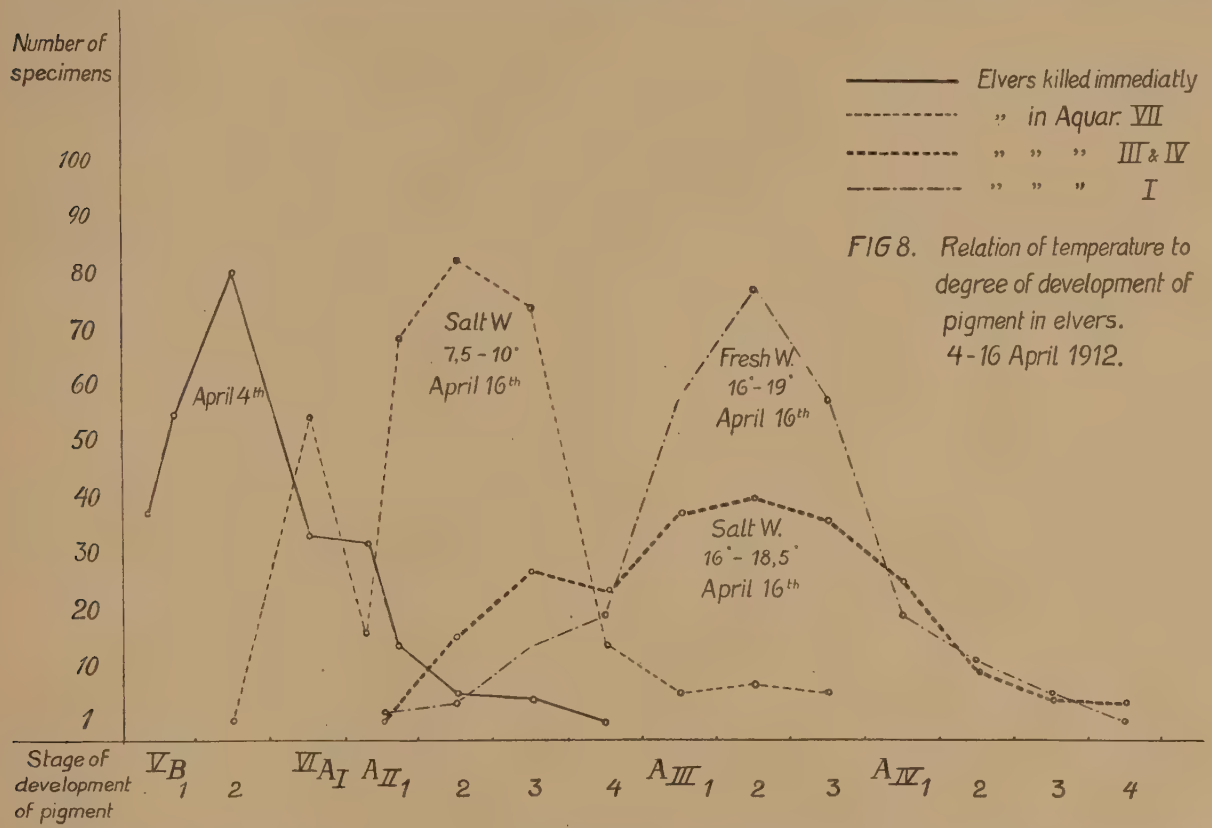

FIG 8. Relation of temperature to degree of development of pigment in elvers. 4-16 April 1912.

the selected period of 12 days, for the rapidity of developement of the pigment, whether the elvers are placed in salt or fresh water, at any rate, with the salinity here in question (abt. 16 ‰). This factor is of no essential importance as compared with the temperature.

If the experimental period be extended, as in the case of aquaria V and VI, at 15°—21° and 8°—16° C. respectively, to about three months, a further developement naturally takes place in both cases in comparison with the first period. The ventrolateral pigment commences to spread preanally, there is, however, now no difference in the direction expected. In comparison with the degree of developement in a number of elvers killed in Aquarium II at the expiration of about $1^1/_2$ months, before the feeding experiments were commenced, we find, especially in Aquarium V, where the conditions of temperature were very nearly identical with those of Aquarium II, the formation of the pigment in the last half of the long period very little advanced. It seems as though the abnormal conditions, among

[1]) For convenience of graphical representation the figures on which the curve for "elvers killed immediately" is based have been divided by 3.

other things the faint light, lack of food, etc., during the long period, have retarded the developement of the pigment, in comparison, as shown in the following, with other sides of the metamorphosis, and this to a greater degree with the higher temperature.

As mentioned above, the investigations in 1911 gave entirely similar results as regards the predominant importance of temperature, at any rate, during the month the experiments lasted, as our "twelve day" experiments in 1912.

They also indicated, — though this has not been subsequently proved with certainty — that neither alteration of the conditions with regard to salinity nor the exclusion of light, has any essential influence on the rapidity of formation of the pigment.

II. REDUCTION IN LENGTH.

All the specimens[1]) were measured after having lain for two months in Formol. The measurements are given below.

Aq. No.	Killed immediately	VII	I	III & IV	II	VI	V
Duration of Experiment in days		12	12	12	46	83	83
Limits of Temperature, C°		7.5—10	16—19	16—18.5	15.5—22	8—16	15—21
Length in mm							
82 81	1						
80 79	2 5						
78 77	6 5	1 1					
76 75	16 38	9 9	3 8	1			
74 73	48 59	16 31	12 28	1			
72 71	70 78	37 41	24 32	16 12	3 4	1	
70 69	92 79	43 33	36 32	17 24	3 7	4 9	2 2
68 67	59 55	35 28	28 20	28 25	9 11	15 19	7 5
66 65	43 38	17 9	18 12	27 22	20 14	20 21	16 24
64 63	15 6	4 5	5 4	22 15	11 7	23 19	26 32
62 61	1 1	2	2	4 4	5 3	17 18	36 25
60 59	1 2			1 1	2	10 5	16 14
58	1					2	6 8
						1	2
Total No.	721	324	265	220	99	184	221
Average length in mm	70.16	70.11	69.71	69.06	67.96	68.34	66.64
Standard deviation, σ	3.42	3.04	2.97	2.92	2.69	2.93	2.78
Probable fluctuations of the average[2])	70.59 69.73	70.68 69.64	70.33 69.09	69.72 68.40	68.87 67.05	69.07 67.61	67.24 66.01

The figures, as well as the graphical representation (fig. 9) indicate that at the expiration of a fortnight from the commencement of the experiment, an actual reduction in length though but slight can already be noticed and only in the samples at high temperature, being distinct and certain in the salt water sample.

[1]) Two specimens from Aq. V & VI not measured, having been utilised for other experiments.

[2]) The "fluctuations of the average" are calculated from five times the probable errors of the averages, as found by the formula $= \pm 5 \cdot 0.6745 \cdot \frac{\sigma}{\sqrt{n}}$ (*Davenport* — Statistical methods. 1904). In these cases, where the averages did not overlap we know the probability to be at least a thousand to one »that the differences observed correspond to true differences in nature«. (*Kyle* — 18th Ann. Rep. Fish. B. Scotland Pt. III.)

The relation of the varying reduction in length to the temperature is still more conspicuous in the specimens which have lived in the aquaria for the 83 days, both with salt water; the average length has here, at 8°—16° C., diminished from 70.16 to 68.34 = *1.8 mm.* while the reduction at 15°—21° is from 70.16 to 66.64 = *3.5 mm.* As regards the regularity or otherwise in the progress of the reduction during the period of experiment nothing is known as yet. Fig. 9 can only be regarded as an approximately accurate picture of same. (Cf. observations from Aq. II etc.)

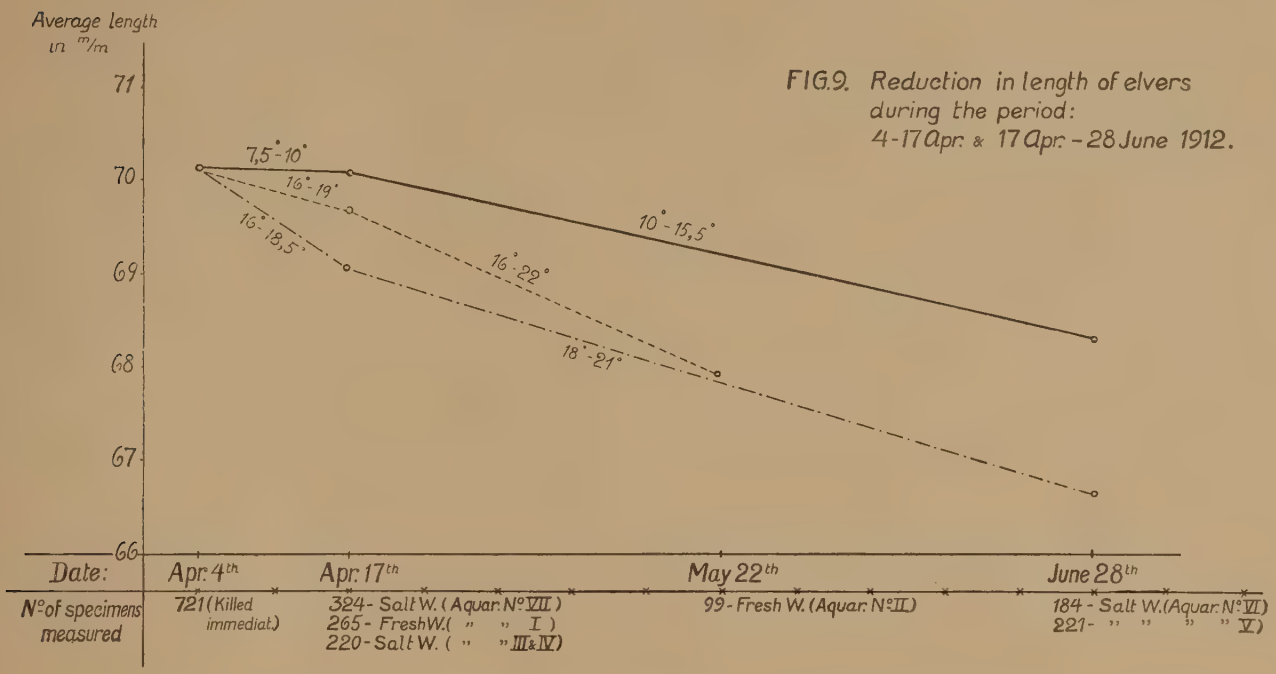

FIG. 9. Reduction in length of elvers during the period: 4-17 Apr. & 17 Apr. - 28 June 1912.

That the metamorphosis is accompanied by a considerable reduction in length has already been pointed out first by GRASSI and CALANDRUCCIO [1]) later by JOHANSEN [1]), SCHMIDT (l. c.) and others. SCHMIDT finds, in two samples of elvers from the west of Ireland (from the River Laune and Valentia Harbour) at stages V and VI respectively, taken on the 8. March and 26. May 1906, a reduction in the average length of from 69.96 to 66.26 mm. i. e., a reduction of abt. *3.7 mm.* in the course of about $2^3/_4$ months, or in other words, values approximating those indicated by our aquarium experiments. As compared with earlier stages, the reduction in length is far more important (up to abt. 1 cm. [SCHMIDT, l. c.]) but our experiments give no further information as to this.

A. C. JOHANSEN (l. c.) gives the average length for metamorphosed elvers on the Danish coasts as abt. 65—68 mm. and estimates the diminution in length at abt. 5 mm. average, for the period from March—April to June.

The length i. e., average length of the elvers at the time of their migration into fresh water, can, however, vary considerably for the same locality from year to year [2]), but the subject has not yet been thoroughly investigated. Measurements of length, together with simultaneous investigation of the degree of pigmentation, made with specimens all treated (preserved) in the same way would probably

[1]) Medd. Komm. f. Havundersøgelser, Fiskeri Bd. I. Nr. 6, 1905.

[2]) Thus in a comparison made by LÜBBERT ("Der Fischerbote" III, 1911, p. 140) of measurements of length of elvers ("at Stage V") from the Bristol Channel, we find the average length varying from 68.10 mm. (1326 spc. May 1903) to 70.62 mm. (375 spc. March 1911) and 75.92 mm. (365 spc. April 1908), the last two samples measured when fresh, the first after treatment with formalin.

furnish some information as to how far the variations in average length are due to varying "age" (degree of developement) of the samples, and how far they must be referred back to the existing variation in size of the full grown Leptocephalus (Stage I) as shown by SCHMIDT (l. c.).

III. LOSS IN WEIGHT.

The "fresh weight"[1]) of the samples has been taken, in order to reveal any possible difference in the loss in weight between the different Aquaria. The average values found are shown below.

Aquarium No	Killed immediately	VII	I	III & IV	II	VI	V
Duration of Experiment in days		12	12	12	46	83	83
Limits of Temperature in C°		7.5—10	16—19	16—18.5	15.5—22	8—16	15—21
No. of specimens	721	324	265	265	99	182	221
Average weight in Gr.	0.204	0.185	9.195	0.170	0.131	0.169	0.135

The weight was determined after the specimens had been carefully dried with filter paper. This method does not give any great accuracy, but the figures obtained yet serve to show, as with the values of average length, a reduction (from the fresh weight) noticeable already at the end of the first period, and most marked in the salt water aquaria at »ordinary temperature«. (No. III—IV). The fresh water does not appear, in spite of the high temperature, to have accelerated the loss in weight to anything like the same degree, not even quite so much as the salt water at the lower temperature (Aq. VII) during the first 14 days. — With the longer experimental period however (46 and 83 days) we find, both with the salt and fresh water samples (Aq. II and V) a far greater reduction in weight at the higher temperature than at the lower, 0.069 gr. (Aq. V) as against 0.035 gr. (Aq. VI). The greatest loss in weight here falls to the elvers in the fresh water Aquarium (Aq. II) after only 46 days. It is impossible as yet to determine whether this is due to the fresh water in conjunction with the continually higher (abt. 1° higher) temperature in Aq. II, or merely to the fact that the loss in weight is greatest during the first part of the experimental period decreasing thereafter. The experiments prove, however, that the difference in loss of weight and length reduction found between Aq. II and V (with salt and fresh water at high temp.) is at any rate immaterial as against the difference in developement which is dependent on a higher or lower temperature.

A comparison with the »fresh weight« given by SCHMIDT for the Leptocephalus (at Stage I) and Elvers (at Stage V) shows the following results:

Stage	Leptocephalus brevirostris	Elvers				
	I	V	V—VI A	VI	VI	VI
Locality	S. W. of Ireland	W. Ireland	N. W. Sealand			
Date	May (1905)	March 8 (1906)	April 2. (1912)	12 days later, high temp.	83 days later, low temp.	83 days later, high temp.
Average weight	1.479 gr	0.328 gr 0.319 gr	0.204 gr	0.170 gr	0.169 gr	0.135 gr
No. examined	12	39	721	220	185	222

[1]) Vide J. SCHMIDT (l. c).

The loss in weight is thus up to abt. 91 % of the weight of Stage I; for several specimens, especially in Aq. V, the loss is even greater; up to abt. 95 % (0.075 gr. pr. average of 30 specimens). These great losses in weight are presumably due, for the most part, to the abnormal conditions in the aquaria, especially the long period of starvation. That the elvers do not under normal conditions, starve during the period of transformation, has been shown by the observation both of SCHMIDT and BOWMAN (vide SCHMIDT, l. c.).

SUMMARY.

Experiments were made in the Spring of 1911 (April—May) and 1912 (April—June) by placing colourless (unpigmented) elvers (Stage V_B) under different outward conditions ɔ: in aquaria, partly with fresh, partly with salt water, some in daylight and some in the dark, some being in open air, and others at indoor temperature. After periods of experiments, varying between 12 and 83 days a closer examination showed, that the progress of the transformation of the elvers from the colourless stage to the darkly pigmented (Stage VI_B) — with simultaneous reduction of length and weight — is more distinctly influenced i. e. accelerated or retarded to a greater degree by temperature than by other outwards conditions, salinity and light.